



# EDGEWOOD

CHEMICAL BIOLOGICAL CENTER

U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-025

DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND  
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING  
OF KAPPLER CPF3 COVERALL  
MODEL 3T436

Robert S. Lindsay  
Terri L. Longworth  
Marcia A. Johnson

ENGINEERING DIRECTORATE

April 1999

Approved for public release, distribution is unlimited.



19990524 068

Aberdeen Proving Ground, MD 21010-5424

DTIC QUALITY INSPECTED 4

### **Disclaimer**

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorizing documents.

## REPORT DOCUMENTATION PAGE

*Form Approved  
OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

|   |   |  |
|---|---|--|
| 1. AGENCY USE ONLY (Leave Blank)  | 2. REPORT DATE  | 3. REPORT TYPE AND DATES COVERED                               |
|   | April 1999  | Final; 98 Mar – 98 May   |
| 4. TITLE AND SUBTITLE<br><b>Domestic Preparedness Program: Liquid Sulfur Mustard and Sarin Challenge/Vapor Penetration Swatch Testing of Kappler CPF3 Coverall, Model 3T436</b>   |   | 5. FUNDING NUMBERS<br><br>None                                 |
| 6. AUTHOR(S)<br>Lindsay, Robert S.; Longworth, Terri L.; and Johnson, Marcia A.   |   |  |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br><br>DIR, ECBC*, ATTN: AMSSB-REN-SO, APG, MD 21010-5424  |   | 8. PERFORMING ORGANIZATION REPORT NUMBER<br><br>ECBC-TR-025    |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br><br>DIR, ECBC, ATTN: AMSSB-RTD-D, APG, MD 21010-5424   |   | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER                 |
| 11. SUPPLEMENTARY NOTES<br><br>*When the work was conducted, the U.S. Army Edgewood Chemical Biological Center (ECBC) was known as the U.S. Army Edgewood Research, Development and Engineering Center (ERDEC).   |   |  |
| 12a. DISTRIBUTION/AVAILABILITY STATEMENT<br><br>Approved for public release; distribution is unlimited.   |   | 12b. DISTRIBUTION CODE   |
| 13. ABSTRACT (Maximum 200 words)<br><br>A Kappler CPF3 Coverall, Model 3T436 (Kappler Safety Group, Guntersville, AL) had swatches taken from six sample positions. These swatches were tested against sulfur mustard (HD) and sarin (GB) in accordance with the U.S. Army Edgewood Research, Development and Engineering Center's (ERDEC) modified static diffusion procedure, which was derived from Test Operations Procedure (TOP) 8-2-501. |   |  |
| 14. SUBJECT TERMS<br>HD      Swatch testing      Chemical protective suits<br>GB      Permeation testing  |   | 15. NUMBER OF PAGES<br>29                                      |
|   |   | 16. PRICE CODE   |
| 17. SECURITY CLASSIFICATION OF REPORT<br><b>UNCLASSIFIED</b>  | 18. SECURITY CLASSIFICATION OF THIS PAGE<br><b>UNCLASSIFIED</b> | 19. SECURITY CLASSIFICATION OF ABSTRACT<br><b>UNCLASSIFIED</b> |
|   |   | 20. LIMITATION OF ABSTRACT<br><b>UL</b>                        |

**Blank**

## Preface

The work described in this report was authorized under the Expert Assistance (Personal Protective Equipment Evaluation) Program for the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)\* Program Director for Domestic Preparedness. The work was started in March 1998 and completed in May 1998.

The use of either trade or manufacturers names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

This report has been approved for public release. Registered users should request additional copies from the Defense Technical Information Center; unregistered users should direct such requests to the National Technical Information Service.

### Acknowledgments

The authors acknowledge Frederick C. Baldauf for his assistance in performing the agent tests.

---

\* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

**Blank**

## CONTENTS

|            |  |    |
|------------|--|----|
| 1.         | INTRODUCTION.....                          | 7  |
| 2.         | MATERIALS AND METHODS.....                 | 7  |
| 2.1        | Suit Description.....                      | 7  |
| 2.2        | Swatch Preparation.....                    | 7  |
| 2.3        | Test Procedure.....                        | 8  |
| 3.         | RESULTS AND DISCUSSION.....                | 11 |
| 3.1        | HD Results.....                            | 11 |
| 3.2        | GB Results.....                            | 11 |
| 3.3        | Material Thickness.....                    | 11 |
| APPENDIXES |  |    |
|            | A-MODIFIED STATIC DIFFUSION PROCEDURE..... | 13 |
|            | B-HD TABLES.....                           | 15 |
|            | C-GB TABLES.....                           | 23 |

## **FIGURES**

|   |   |    |
|---|---|----|
| 1 | Kappler CPF3 Coverall Label.....          | 8  |
| 2 | TOP Permeation Cell.....                  | 9  |
| 3 | Environmental Cabinet.....                | 10 |
| 4 | MINICAMS and Stream Selection System..... | 10 |

DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND  
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING  
OF KAPPLER CPF3 COVERALL  
MODEL 3T436

1. INTRODUCTION

Under the Domestic Preparedness (DP) Expert Assistance (Personal Protective Equipment (PPE) Evaluation) Program, the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)\* was tasked to perform testing of swatches taken from commercially-available Level B suits currently being used by emergency responders from cities involved in this program. The testing was performed by the Design Evaluation Group, Surety Team, Methodology, Instrumentation and Test Office, Engineering Directorate. The test procedure was jointly developed and agreed upon by ERDEC and the U. S. Army Natick, Research, Development and Engineering Center (NRDEC) (written communication, M. Chin, NRDEC, 1 May 97).

2. MATERIALS AND METHODS

2.1 Suit Description.

The Kappler CPF3 coverall was manufactured by Kappler Safety Group (Guntersville, AL) and was brown in color. The model number was 3T436. Figure 1 is a digital photograph of the label found inside the suit.

2.2 Swatch Preparation.

The day before testing was scheduled to begin, the suit was picked up from Mask Issue and transported to the laboratory. The suit was folded up for transport and was hung on a hanger once in the laboratory. The suit was stored this way during and after testing.

The swatch locations to be sampled were given in the PPE Test Team Work Contract for Level A Ensembles (written communication, R. Belmonte, Engineering Directorate, ERDEC, 25 June 1997). These swatch sampling locations were listed as suit material (SM), suit seam (SS), visor material (VM), zipper/suit material seam (ZP), glove (GL), and visor material/suit material seam (SV). The coverall did not have a visor or gloves but did have boots. The decision was made to take swatches from these six locations; the crotch seam (CS), boot material (BM), boot seam (BS), (ZP), SM, and SS. The swatches were normally cut the day before testing and conditioned overnight at the test conditions. For a Monday test, swatches were cut Friday and conditioned over the weekend. Normally, the swatches would be laid in the environmental cabinet for conditioning.

---

\* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

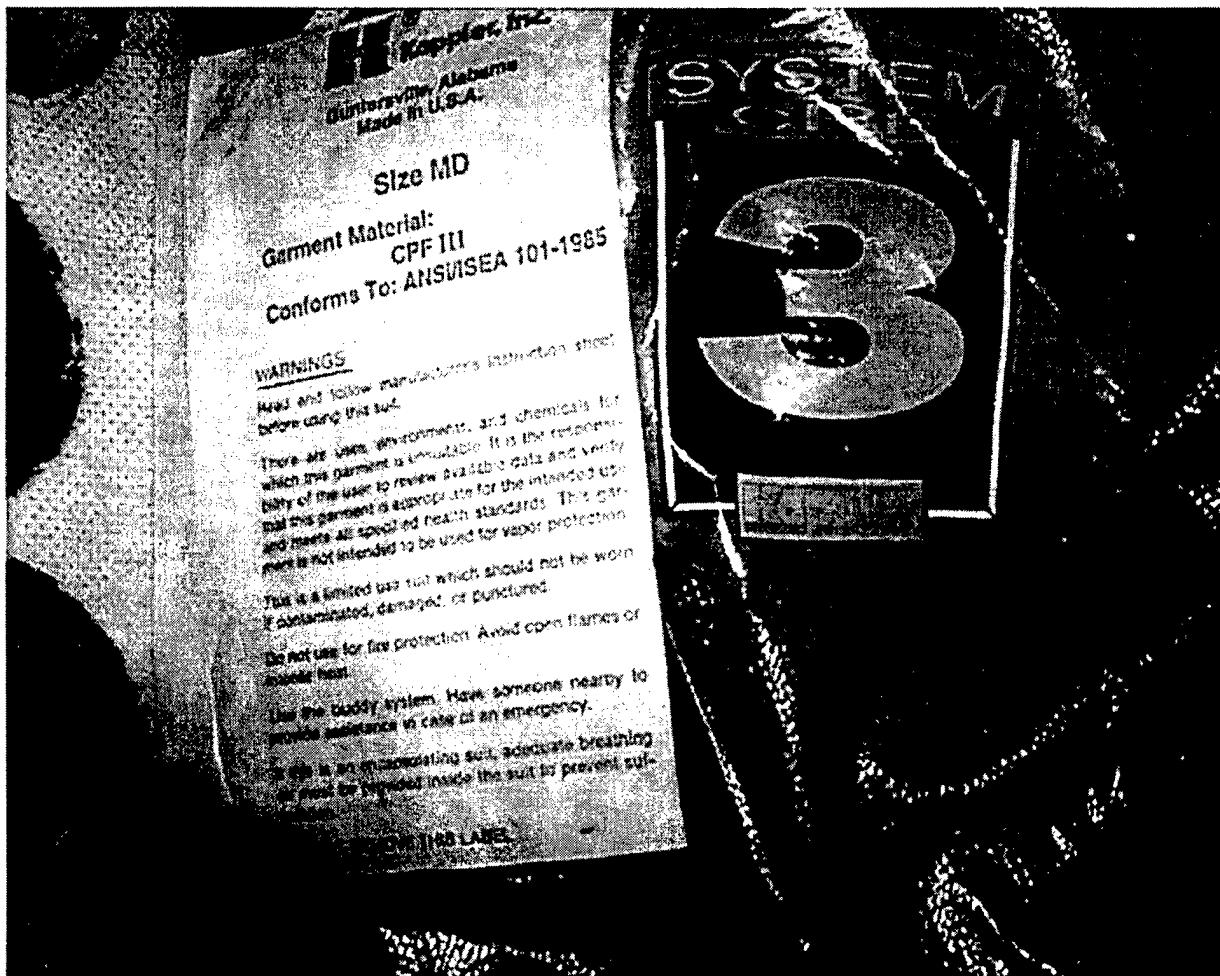


Figure 1. Kappler CPF3 Coverall Label

The swatches were numbered in accordance with the PPE Test Team Work Instructions (written communication, R. Belmonte, Engineering Directorate, ERDEC, 11 June 1997); for example LC-KPL-SM-01, etc. All swatches were cut in triplicate, one at a time on a sample press. The swatch diameter was 2 in.

The reference material was 80-mil silicone, using the M45 mask formulation, prepared by Malcolm Little of the M45 mask team. Preparation and conditioning were the same as for the suit swatches.

## 2.3

### Test Procedure.

The procedure agreed upon by ERDEC and NRDEC was derived from the report entitled, "Permeation and Penetration Testing of Air Permeable, Semi-permeable

and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing)" dated 3 March 1997. The Modified Static Diffusion Procedure is found in Appendix A of this report. Subsequent to the agreement, ERDEC personnel determined that the usage of the 80-mil silicone did not meet the definition of a positive control. The silicone swatches were used as an indication of agent vapor permeation. Equipment and schedule limitations prevented the use of negative controls. The terminology of the test procedure was not modified to reflect these changes.

The TOP permeation cell was used and a digital photograph of one is given as Figure 2.

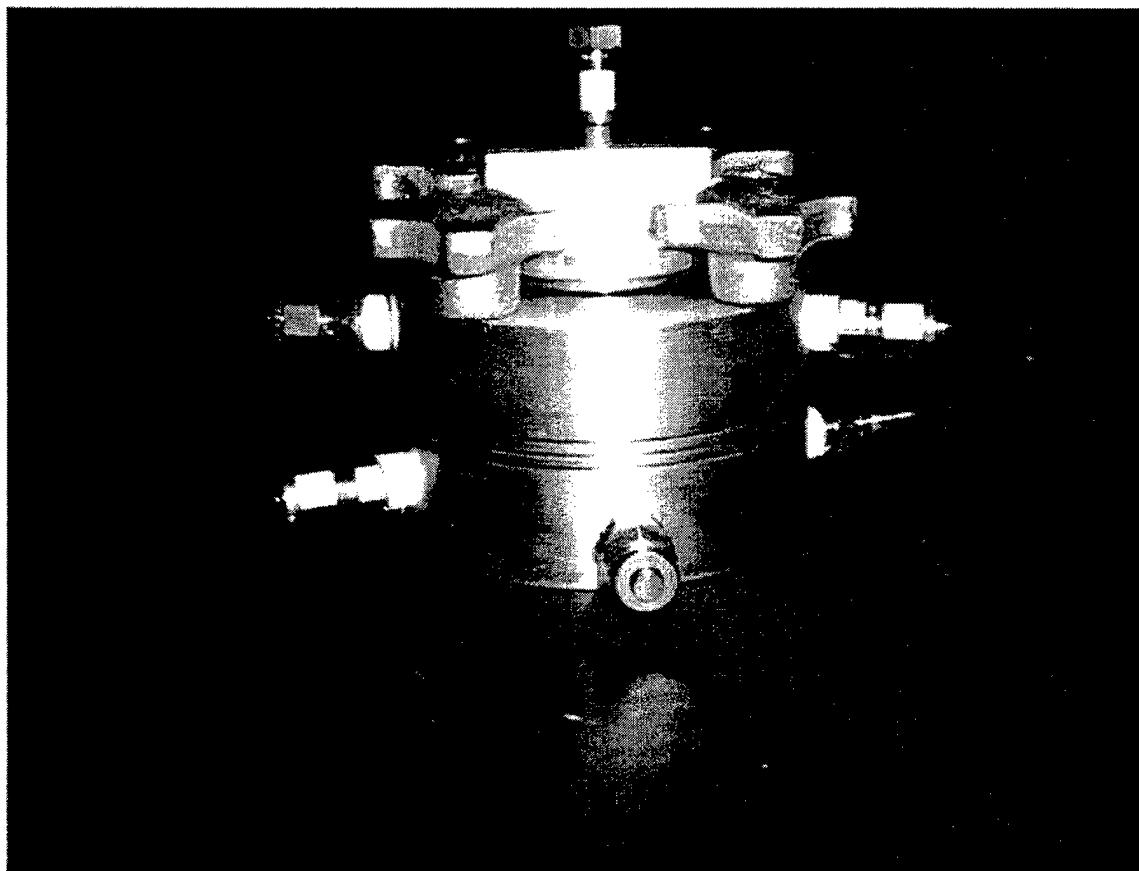


Figure 2. TOP Permeation Cell

The remainder of the test apparatus consisted of:

- Plastic environmental cabinet with sliding doors containing a permeation cell rack, circulating blower, and heat source (Figure 3).
- Flow/temperature/relative humidity control system; (Miller-Nelson Research Corporation, Monterey, CA) model HCS-410.

- Flow control system; (Tylan General Incorporated, Torrance, CA) Dynamass model FM-8.
- Mass flow controllers; (Tylan General Incorporated, Torrance, CA) model FC-260.
- Calibrated Vaisala humidity and temperature indicator.
- MINICAMS, serial number 1860, and Stream Selection System (CMS Research Corporation, Birmingham, AL). Illustrated in Figure 4.

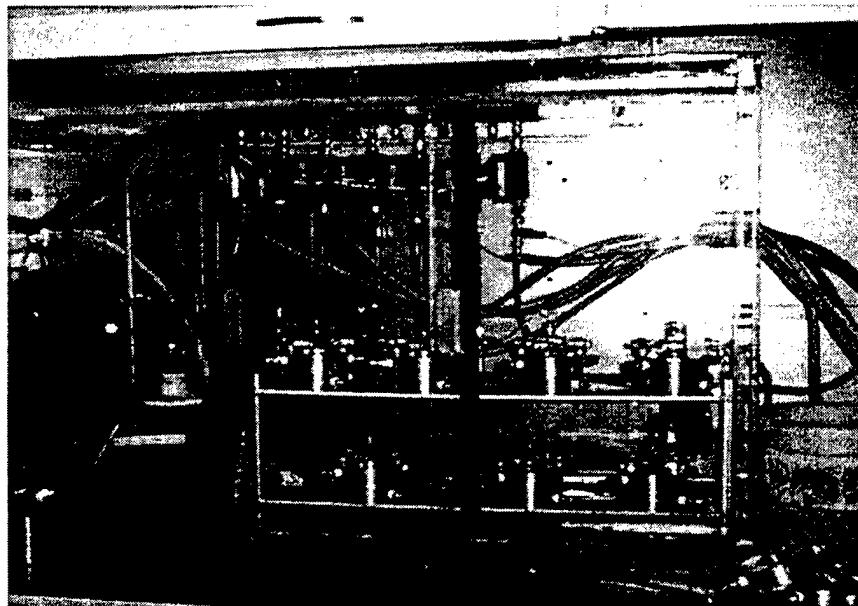


Figure 3. Environmental Cabinet

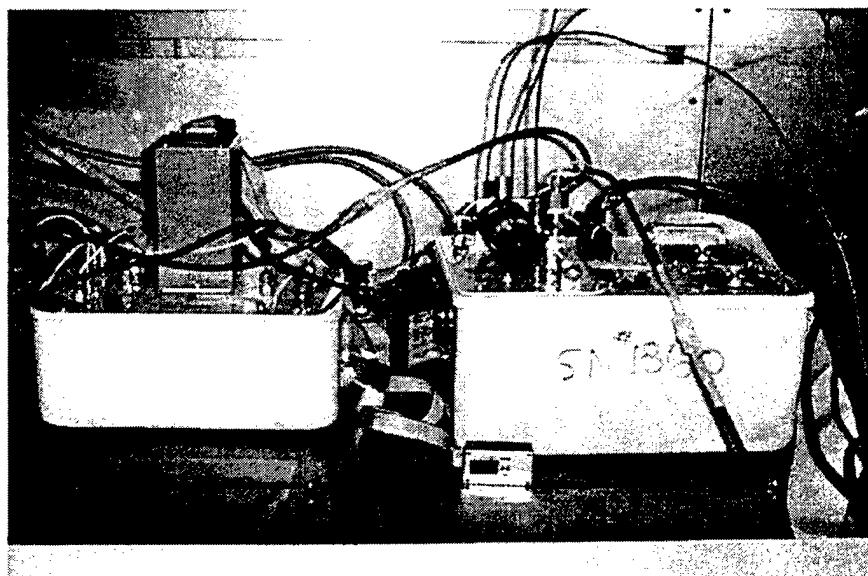


Figure 4. MINICAMS and Stream Selection System

### 3. RESULTS AND DISCUSSION

#### 3.1 HD Results.

The HD permeation results are given in Appendix B as Tables B-1 through B-6. Average elapsed time was not used. The actual time that each swatch was sampled by the MINICAMS is shown.

The MINICAMS minimum detection limit was 1.0 ng for all test days. There were no visible effects on any of the materials from HD exposure. Cumulative permeation for all swatches was similar to the suit material.

The average temperature was 90.9 °F, and 47.7% RH was the average for all tests. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used.

#### 3.2 GB Results.

The GB permeation results are given in Appendix C as Tables C-1 through C-6.

The MINICAMS minimum detection limit was 0.4 ng for all test days. There were no visible effects on any of the materials from GB exposure. Cumulative permeation was highest for the suit material, all other swatches had similar or smaller cumulative permeation results.

The average temperature was 90.0 °F and 37.9% RH was the average for all tests. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used.

#### 3.3 Material Thickness.

Prior to conducting the HD and GB testing, thickness measurements of the suit material and the boot material were made. A swatch of material was cut from the suit immediately adjacent to the area from which the agent swatches were taken. Twenty-four thickness measurements were taken on each swatch using an Ames dial comparator (B. C. Ames Company, Waltham, MA). The average thickness of the suit material swatch was 0.022 in. The average thickness of the boot material swatch was 0.025 in.

**Blank**

**APPENDIX A**  
**MODIFIED STATIC DIFFUSION PROCEDURE**

## **MODIFIED STATIC DIFFUSION TEST**

This test procedure was adapted from the "Semipermeable and Impermeable Materials Static Diffusion Penetration Testing (Liquid Agent Challenge/Vapor Penetration; delta p = 0, Single Flow Test) given in Test Operations Procedure (TOP) 8-2-501 dated 3 Mar 97.

The following procedure will be used:

Upon receipt of a suit, all available information concerning the suit will be recorded; date of manufacture, lot number, serial number, materials of construction, etc.

From each suit, 3 each 1 and 15/16 in. diameter material swatches will be taken for HD and a like number taken for GB. Depending upon the suit configuration, three seam swatches (same diameter) will be taken plus triplicate swatches of other flat components such as other seams, visor, gloves, booties, etc. for HD and an equal number for GB. Each swatch will be placed in an airtight bag and given a unique serial number which will be placed on the bag. A list of serial numbers will be kept with the swatches.

The environmental chamber will be controlled at a temperature of 90 +/- 2 °F , and the maximum achievable RH without occurrence of condensation (70% +/- 10% RH). The temperature and RH readings will be checked weekly with a calibrated meter. The test cell air will be drawn from the chamber air. There will be no system control and data acquisition system. The temperature and RH will be recorded in a computer file. Flow rates will be manually recorded. There will be no differential pressure monitoring since differential pressure gages of sufficient sensitivity are not available.

The TOP test cell will be used. When assembling, the cell lugs will be tightened by hand to finger tight. The flow rate beneath each swatch will be 1 L/min which will be controlled by a linear mass flow controller. The flows will be checked with a calibrated test meter weekly. Each test cell will be checked for leaks after assembly by connecting it to the vacuum source and checking that the inlet flow is the same as the outlet flow on the mass flow controller (cell lugs will be retightened if flows don't match).

The samples will serve as their own negative controls while being preconditioned overnight by being MINICAMS monitored. Eighty mil silicone will be used as a positive control for each test (six suit swatches and one silicone swatch).

Agents GB and HD will be used. The contamination density will be 10 g/m<sup>2</sup> (eight each 1 µl HD droplets or ten each 1 µl GB droplets). A robotic agent application system is not available. The agent will be applied using the click/touch method with a Hamilton repeating dispenser.

Seven swatches will be tested at once. MINICAMS with stream selection system will monitor vapor penetration with a 3-min cycle. There will be three blank sampling intervals following the control. Each swatch will be sampled once every 30 min. The MINICAMS will be standardized weekly.

The test length will be 24 hr.

The test cells and o-rings will be aerated between uses. No other cleaning method will be used.

The data to be reported are cumulative penetration (ng/cm<sup>2</sup>) versus average elapsed time (minutes) for each swatch. The average elapsed time is the sum of the elapsed time for swatch 1 and the elapsed time for swatch 6 divided by 2. All recorded data will be placed in laboratory notebooks and a technical report will be drafted at the conclusion of this effort.

## **Appendix A**

**APPENDIX B**  
**HD TABLES**

**Table B-1. Kappler CPF III Suit Material vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 22 April 1998**

| Cumulative Penetration (ng/cm <sup>2</sup> ) |          |         |          |         |          |
|--|----------|---------|----------|---------|----------|
| Minutes                                      | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
| 3  | 1        | 6       | 1        | 9       | 2        |
| 33   | 12       | 36      | 11       | 39      | 11       |
| 63   | 20       | 66      | 19       | 69      | 17       |
| 93   | 27       | 96      | 26       | 99      | 23       |
| 123  | 37       | 126     | 36       | 129     | 32       |
| 153  | 52       | 156     | 49       | 159     | 43       |
| 183  | 71       | 186     | 66       | 189     | 56       |
| 213  | 94       | 216     | 86       | 219     | 71       |
| 243  | 120      | 246     | 109      | 249     | 90       |
| 273  | 149      | 276     | 134      | 279     | 110      |
| 303  | 181      | 306     | 160      | 309     | 130      |
| 333  | 216      | 336     | 188      | 339     | 152      |
| 363  | 257      | 366     | 218      | 369     | 177      |
| 393  | 303      | 396     | 251      | 399     | 202      |
| 423  | 354      | 426     | 288      | 429     | 229      |
| 453  | 409      | 456     | 326      | 459     | 258      |
| 483  | 470      | 486     | 366      | 489     | 290      |
| 513  | 534      | 516     | 409      | 519     | 325      |
| 543  | 602      | 546     | 453      | 549     | 360      |
| 573  | 673      | 576     | 499      | 579     | 398      |
| 603  | 746      | 606     | 548      | 609     | 438      |
| 633  | 821      | 636     | 598      | 639     | 480      |
| 663  | 897      | 666     | 650      | 669     | 523      |
| 693  | 975      | 696     | 702      | 699     | 566      |
| 723  | 1054     | 726     | 756      | 729     | 612      |
| 753  | 1135     | 756     | 812      | 759     | 658      |
| 783  | 1218     | 786     | 869      | 789     | 707      |
| 813  | 1302     | 816     | 930      | 819     | 758      |
| 843  | 1389     | 846     | 994      | 849     | 813      |
| 873  | 1479     | 876     | 1061     | 879     | 870      |
| 903  | 1569     | 906     | 1131     | 909     | 929      |
| 933  | 1660     | 936     | 1202     | 939     | 989      |
| 963  | 1753     | 966     | 1275     | 969     | 1050     |
| 993  | 1846     | 996     | 1349     | 999     | 1112     |
| 1023   | 1937     | 1026    | 1423     | 1029    | 1174     |
| 1053   | 2027     | 1056    | 1497     | 1059    | 1236     |
| 1083   | 2115     | 1086    | 1571     | 1089    | 1297     |
| 1114   | 2201     | 1117    | 1644     | 1120    | 1358     |
| 1144   | 2287     | 1147    | 1717     | 1150    | 1419     |
| 1174   | 2371     | 1177    | 1790     | 1180    | 1478     |
| 1204   | 2453     | 1207    | 1862     | 1210    | 1539     |
| 1234   | 2536     | 1237    | 1934     | 1240    | 1600     |
| 1264   | 2616     | 1267    | 2007     | 1270    | 1660     |
| 1295   | 2695     | 1298    | 2079     | 1301    | 1720     |
| 1325   | 2772     | 1328    | 2150     | 1331    | 1780     |
| 1355   | 2848     | 1358    | 2221     | 1361    | 1838     |
| 1385   | 2922     | 1388    | 2290     | 1391    | 1895     |
| 1415   | 2994     | 1418    | 2358     | 1421    | 1952     |

Table B-2. Kappler CPF III Suit Seam vs. HD Liquid, 10 g/m<sup>2</sup>  
 Modified Static Diffusion Test, 22 April 1998  
 Cumulative Penetration (ng/cm<sup>2</sup>)

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
|---------|----------|---------|----------|---------|----------|
| 12      | 4        | 15      | 3        | 18      | 3        |
| 42      | 19       | 45      | 14       | 48      | 11       |
| 72      | 31       | 75      | 24       | 78      | 17       |
| 102     | 44       | 105     | 36       | 108     | 24       |
| 132     | 60       | 135     | 52       | 138     | 31       |
| 162     | 80       | 165     | 73       | 168     | 41       |
| 192     | 102      | 195     | 98       | 198     | 52       |
| 222     | 128      | 225     | 127      | 228     | 67       |
| 252     | 156      | 255     | 161      | 258     | 85       |
| 282     | 188      | 285     | 199      | 288     | 110      |
| 312     | 224      | 315     | 241      | 318     | 141      |
| 342     | 263      | 345     | 288      | 348     | 179      |
| 372     | 307      | 375     | 339      | 378     | 224      |
| 402     | 353      | 405     | 393      | 408     | 277      |
| 432     | 402      | 435     | 450      | 438     | 334      |
| 462     | 455      | 465     | 510      | 468     | 394      |
| 492     | 509      | 495     | 572      | 498     | 458      |
| 522     | 566      | 525     | 635      | 528     | 523      |
| 552     | 624      | 555     | 700      | 558     | 590      |
| 582     | 683      | 585     | 766      | 588     | 658      |
| 612     | 743      | 615     | 834      | 618     | 726      |
| 642     | 804      | 645     | 903      | 648     | 794      |
| 672     | 866      | 675     | 971      | 678     | 861      |
| 702     | 929      | 705     | 1040     | 708     | 928      |
| 732     | 992      | 735     | 1111     | 738     | 995      |
| 762     | 1057     | 765     | 1183     | 768     | 1063     |
| 792     | 1122     | 795     | 1257     | 798     | 1131     |
| 822     | 1190     | 825     | 1332     | 828     | 1201     |
| 852     | 1259     | 855     | 1411     | 858     | 1273     |
| 882     | 1329     | 885     | 1490     | 888     | 1344     |
| 912     | 1400     | 915     | 1571     | 918     | 1416     |
| 942     | 1472     | 945     | 1654     | 948     | 1489     |
| 972     | 1544     | 975     | 1737     | 978     | 1561     |
| 1002    | 1616     | 1005    | 1820     | 1008    | 1633     |
| 1032    | 1687     | 1035    | 1903     | 1038    | 1703     |
| 1062    | 1755     | 1065    | 1984     | 1068    | 1772     |
| 1093    | 1824     | 1096    | 2066     | 1099    | 1842     |
| 1123    | 1892     | 1126    | 2147     | 1129    | 1910     |
| 1153    | 1959     | 1156    | 2227     | 1159    | 1976     |
| 1183    | 2025     | 1186    | 2306     | 1189    | 2042     |
| 1213    | 2091     | 1216    | 2385     | 1219    | 2106     |
| 1243    | 2157     | 1246    | 2463     | 1249    | 2171     |
| 1274    | 2222     | 1277    | 2540     | 1280    | 2234     |
| 1304    | 2285     | 1307    | 2617     | 1310    | 2297     |
| 1334    | 2347     | 1337    | 2693     | 1340    | 2358     |
| 1364    | 2408     | 1367    | 2766     | 1370    | 2417     |
| 1394    | 2468     | 1397    | 2840     | 1400    | 2476     |
| 1424    | 2528     | 1427    | 2913     | 1430    | 2535     |

Appendix B

**Table B-3. Kappler CPF III Boot Material vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 21 April 1998**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
|---------|----------|---------|----------|---------|----------|
| 1       | 0        | 4       | 1        | 7       | 1        |
| 31      | 11       | 34      | 10       | 37      | 8        |
| 61      | 22       | 64      | 18       | 67      | 14       |
| 91      | 32       | 94      | 26       | 97      | 20       |
| 121     | 48       | 124     | 38       | 127     | 29       |
| 151     | 70       | 154     | 51       | 157     | 41       |
| 181     | 97       | 184     | 68       | 187     | 55       |
| 211     | 128      | 214     | 91       | 217     | 72       |
| 241     | 161      | 244     | 117      | 247     | 91       |
| 271     | 197      | 274     | 144      | 277     | 111      |
| 301     | 234      | 304     | 173      | 307     | 133      |
| 331     | 274      | 334     | 205      | 337     | 157      |
| 361     | 315      | 364     | 236      | 367     | 182      |
| 391     | 357      | 394     | 269      | 397     | 209      |
| 421     | 400      | 424     | 302      | 427     | 236      |
| 451     | 445      | 454     | 337      | 457     | 264      |
| 481     | 491      | 484     | 371      | 487     | 292      |
| 511     | 536      | 514     | 405      | 517     | 320      |
| 541     | 582      | 544     | 440      | 547     | 349      |
| 571     | 628      | 574     | 474      | 577     | 378      |
| 601     | 676      | 604     | 510      | 607     | 408      |
| 631     | 727      | 634     | 549      | 637     | 441      |
| 661     | 779      | 664     | 590      | 667     | 477      |
| 691     | 833      | 694     | 636      | 697     | 516      |
| 721     | 889      | 724     | 684      | 727     | 558      |
| 751     | 947      | 754     | 737      | 757     | 603      |
| 781     | 1007     | 784     | 794      | 787     | 652      |
| 811     | 1067     | 814     | 854      | 817     | 705      |
| 841     | 1128     | 844     | 917      | 847     | 760      |
| 871     | 1190     | 874     | 984      | 877     | 817      |
| 901     | 1251     | 904     | 1052     | 907     | 877      |
| 931     | 1313     | 934     | 1123     | 937     | 940      |
| 961     | 1373     | 964     | 1195     | 967     | 1002     |
| 991     | 1434     | 994     | 1266     | 997     | 1065     |
| 1021    | 1493     | 1024    | 1336     | 1027    | 1128     |
| 1051    | 1550     | 1054    | 1405     | 1057    | 1191     |
| 1081    | 1606     | 1084    | 1473     | 1087    | 1255     |
| 1111    | 1663     | 1114    | 1541     | 1117    | 1318     |
| 1141    | 1718     | 1144    | 1607     | 1147    | 1381     |
| 1171    | 1774     | 1174    | 1674     | 1177    | 1444     |
| 1201    | 1829     | 1204    | 1742     | 1207    | 1508     |
| 1231    | 1884     | 1234    | 1810     | 1237    | 1573     |
| 1261    | 1937     | 1264    | 1876     | 1267    | 1637     |
| 1291    | 1990     | 1294    | 1941     | 1297    | 1699     |
| 1321    | 2043     | 1324    | 2005     | 1327    | 1761     |
| 1351    | 2095     | 1354    | 2068     | 1357    | 1822     |
| 1381    | 2145     | 1384    | 2128     | 1387    | 1883     |
| 1411    | 2196     | 1414    | 2190     | 1417    | 1943     |

## Appendix B

**Table B-4. Kappler CPF III Boot Seam vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 16 April 1998**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch |
|---------|----------|---------|----------|---------|--------|
| 10      | 0        | 13      | 0        | 16      | 0      |
| 40      | 0        | 43      | 0        | 46      | 0      |
| 70      | 0        | 73      | 0        | 76      | 0      |
| 100     | 0        | 103     | 0        | 106     | 0      |
| 131     | 5        | 134     | 3        | 137     | 0      |
| 161     | 25       | 164     | 12       | 167     | 4      |
| 191     | 66       | 194     | 31       | 197     | 14     |
| 221     | 129      | 224     | 66       | 227     | 31     |
| 251     | 205      | 254     | 118      | 257     | 60     |
| 281     | 289      | 284     | 181      | 287     | 100    |
| 312     | 376      | 315     | 252      | 318     | 150    |
| 342     | 467      | 345     | 328      | 348     | 207    |
| 372     | 561      | 375     | 408      | 378     | 269    |
| 402     | 655      | 405     | 490      | 408     | 333    |
| 432     | 751      | 435     | 573      | 438     | 401    |
| 462     | 847      | 465     | 657      | 468     | 471    |
| 493     | 945      | 496     | 743      | 499     | 544    |
| 523     | 1044     | 526     | 828      | 529     | 618    |
| 553     | 1143     | 556     | 913      | 559     | 694    |
| 583     | 1240     | 586     | 996      | 589     | 770    |
| 613     | 1337     | 616     | 1079     | 619     | 845    |
| 643     | 1433     | 646     | 1161     | 649     | 919    |
| 674     | 1528     | 677     | 1242     | 680     | 991    |
| 704     | 1621     | 707     | 1319     | 710     | 1061   |
| 734     | 1713     | 737     | 1395     | 740     | 1130   |
| 764     | 1804     | 767     | 1470     | 770     | 1200   |
| 794     | 1895     | 797     | 1546     | 800     | 1271   |
| 824     | 1987     | 827     | 1623     | 830     | 1341   |
| 855     | 2078     | 858     | 1700     | 861     | 1412   |
| 885     | 2170     | 888     | 1776     | 891     | 1482   |
| 915     | 2261     | 918     | 1853     | 921     | 1553   |
| 945     | 2353     | 948     | 1929     | 951     | 1623   |
| 975     | 2445     | 978     | 2006     | 981     | 1693   |
| 1005    | 2537     | 1008    | 2081     | 1011    | 1762   |
| 1036    | 2628     | 1039    | 2156     | 1042    | 1831   |
| 1066    | 2718     | 1069    | 2230     | 1072    | 1898   |
| 1096    | 2808     | 1099    | 2304     | 1102    | 1965   |
| 1126    | 2897     | 1129    | 2377     | 1132    | 2032   |
| 1156    | 2997     | 1159    | 2460     | 1162    | 2110   |
| 1186    | 3110     | 1189    | 2555     | 1192    | 2201   |
| 1217    | 3228     | 1220    | 2655     | 1223    | 2294   |
| 1247    | 3345     | 1250    | 2754     | 1253    | 2386   |
| 1277    | 3460     | 1280    | 2851     | 1283    | 2474   |
| 1307    | 3566     | 1310    | 2939     | 1313    | 2551   |
| 1337    | 3658     | 1340    | 3014     | 1343    | 2615   |
| 1367    | 3742     | 1370    | 3081     | 1373    | 2671   |
| 1398    | 3824     | 1401    | 3146     | 1404    | 2726   |
| 1428    | 3907     | 1431    | 3209     | 1434    | 2779   |

Appendix B

**Table B-5. Kappler CPF III Crotch Seam vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 16 April 1998**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch |
|---------|----------|---------|----------|---------|--------|
| 1       | 0        | 4       | 0        | 7       | 0      |
| 31      | 0        | 34      | 0        | 37      | 0      |
| 61      | 0        | 64      | 0        | 67      | 0      |
| 91      | 3        | 94      | 0        | 97      | 3      |
| 122     | 11       | 125     | 4        | 128     | 12     |
| 152     | 34       | 155     | 14       | 158     | 41     |
| 182     | 78       | 185     | 39       | 188     | 98     |
| 212     | 140      | 215     | 83       | 218     | 176    |
| 242     | 214      | 245     | 143      | 248     | 267    |
| 272     | 296      | 275     | 216      | 278     | 364    |
| 303     | 384      | 306     | 295      | 309     | 466    |
| 333     | 476      | 336     | 378      | 339     | 572    |
| 363     | 572      | 366     | 465      | 369     | 680    |
| 393     | 668      | 396     | 552      | 399     | 788    |
| 423     | 766      | 426     | 640      | 429     | 898    |
| 453     | 865      | 456     | 730      | 459     | 1009   |
| 484     | 964      | 487     | 820      | 490     | 1120   |
| 514     | 1064     | 517     | 909      | 520     | 1232   |
| 544     | 1164     | 547     | 997      | 550     | 1343   |
| 574     | 1261     | 577     | 1085     | 580     | 1452   |
| 604     | 1357     | 607     | 1172     | 610     | 1559   |
| 634     | 1452     | 637     | 1258     | 640     | 1663   |
| 665     | 1545     | 668     | 1341     | 671     | 1764   |
| 695     | 1635     | 698     | 1423     | 701     | 1862   |
| 725     | 1722     | 728     | 1505     | 731     | 1958   |
| 755     | 1809     | 758     | 1585     | 761     | 2052   |
| 785     | 1897     | 788     | 1665     | 791     | 2144   |
| 815     | 1983     | 818     | 1746     | 821     | 2236   |
| 846     | 2069     | 849     | 1827     | 852     | 2326   |
| 876     | 2155     | 879     | 1908     | 882     | 2414   |
| 906     | 2238     | 909     | 1989     | 912     | 2500   |
| 936     | 2320     | 939     | 2069     | 942     | 2583   |
| 966     | 2401     | 969     | 2150     | 972     | 2664   |
| 996     | 2481     | 999     | 2230     | 1002    | 2743   |
| 1027    | 2560     | 1030    | 2309     | 1033    | 2819   |
| 1057    | 2638     | 1060    | 2388     | 1063    | 2892   |
| 1087    | 2714     | 1090    | 2466     | 1093    | 2963   |
| 1117    | 2788     | 1120    | 2542     | 1123    | 3033   |
| 1147    | 2867     | 1150    | 2626     | 1153    | 3108   |
| 1177    | 2960     | 1180    | 2723     | 1183    | 3196   |
| 1208    | 3061     | 1211    | 2826     | 1214    | 3288   |
| 1238    | 3162     | 1241    | 2930     | 1244    | 3378   |
| 1268    | 3261     | 1271    | 3031     | 1274    | 3467   |
| 1298    | 3355     | 1301    | 3125     | 1304    | 3548   |
| 1328    | 3438     | 1331    | 3206     | 1334    | 3616   |
| 1358    | 3511     | 1361    | 3279     | 1364    | 3674   |
| 1389    | 3582     | 1392    | 3348     | 1395    | 3728   |
| 1419    | 3653     | 1422    | 3416     | 1425    | 3781   |

Appendix B

**Table B-6. Kappler CPF III Zipper/Material Interface vs. HD Liquid, 10 g/m<sup>2</sup>  
Modified Static Diffusion Test, 21 April 1998**

| Cumulative Penetration (ng/cm <sup>2</sup> ) |          |         |          |         |          |
|--|----------|---------|----------|---------|----------|
| Minutes                                      | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
| 10   | 1        | 13      | 2        | 16      | 3        |
| 40   | 9        | 43      | 10       | 46      | 11       |
| 70   | 14       | 73      | 17       | 76      | 18       |
| 100  | 17       | 103     | 24       | 106     | 26       |
| 130  | 17       | 133     | 29       | 136     | 30       |
| 160  | 23       | 163     | 35       | 166     | 36       |
| 190  | 35       | 193     | 47       | 196     | 47       |
| 220  | 49       | 223     | 60       | 226     | 59       |
| 250  | 64       | 253     | 74       | 256     | 72       |
| 280  | 81       | 283     | 90       | 286     | 86       |
| 310  | 100      | 313     | 108      | 316     | 101      |
| 340  | 120      | 343     | 126      | 346     | 118      |
| 370  | 141      | 373     | 145      | 376     | 136      |
| 400  | 163      | 403     | 165      | 406     | 154      |
| 430  | 185      | 433     | 186      | 436     | 173      |
| 460  | 208      | 463     | 208      | 466     | 193      |
| 490  | 232      | 493     | 231      | 496     | 212      |
| 520  | 255      | 523     | 254      | 526     | 232      |
| 550  | 279      | 553     | 278      | 556     | 253      |
| 580  | 303      | 583     | 303      | 586     | 275      |
| 610  | 329      | 613     | 329      | 616     | 298      |
| 640  | 357      | 643     | 359      | 646     | 322      |
| 670  | 388      | 673     | 394      | 676     | 351      |
| 700  | 423      | 703     | 434      | 706     | 383      |
| 730  | 462      | 733     | 478      | 736     | 419      |
| 760  | 506      | 763     | 527      | 766     | 459      |
| 790  | 554      | 793     | 579      | 796     | 504      |
| 820  | 607      | 823     | 636      | 826     | 553      |
| 850  | 664      | 853     | 696      | 856     | 607      |
| 880  | 725      | 883     | 760      | 886     | 665      |
| 910  | 790      | 913     | 827      | 916     | 726      |
| 940  | 856      | 943     | 895      | 946     | 789      |
| 970  | 923      | 973     | 965      | 976     | 855      |
| 1000   | 991      | 1003    | 1036     | 1006    | 921      |
| 1030   | 1060     | 1033    | 1107     | 1036    | 988      |
| 1060   | 1128     | 1063    | 1176     | 1066    | 1056     |
| 1090   | 1196     | 1093    | 1246     | 1096    | 1124     |
| 1120   | 1264     | 1123    | 1317     | 1126    | 1193     |
| 1150   | 1331     | 1153    | 1387     | 1156    | 1262     |
| 1180   | 1398     | 1183    | 1458     | 1186    | 1332     |
| 1210   | 1466     | 1213    | 1529     | 1216    | 1404     |
| 1240   | 1533     | 1243    | 1600     | 1246    | 1476     |
| 1270   | 1600     | 1273    | 1670     | 1276    | 1548     |
| 1300   | 1666     | 1303    | 1739     | 1306    | 1620     |
| 1330   | 1732     | 1333    | 1807     | 1336    | 1691     |
| 1360   | 1796     | 1363    | 1874     | 1366    | 1761     |
| 1390   | 1860     | 1393    | 1940     | 1396    | 1831     |
| 1420   | 1924     | 1423    | 2008     | 1426    | 1901     |

Appendix B

**Blank**

## **APPENDIX C**

### **GB TABLES**

**Table C-1. Kappler CPF III Suit Material vs. GB Liquid, 10 g/m<sup>2</sup>  
Modified Static Diffusion Test, 14 April 1998**

| Cumulative Penetration (ng/cm <sup>2</sup> ) |          |         |          |         |          |
|--|----------|---------|----------|---------|----------|
| Minutes                                      | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
| 0  | 0        | 3       | 1        | 6       | 1        |
| 30   | 415      | 33      | 70       | 36      | 51       |
| 59   | 1054     | 62      | 191      | 65      | 141      |
| 89   | 1464     | 92      | 308      | 95      | 235      |
| 119  | 1813     | 122     | 416      | 125     | 323      |
| 149  | 2098     | 152     | 513      | 155     | 402      |
| 179  | 2346     | 182     | 602      | 185     | 475      |
| 209  | 2564     | 212     | 684      | 215     | 542      |
| 239  | 2762     | 242     | 760      | 245     | 603      |
| 269  | 2936     | 272     | 832      | 275     | 662      |
| 299  | 3096     | 302     | 899      | 305     | 717      |
| 329  | 3254     | 332     | 967      | 335     | 771      |
| 359  | 3402     | 362     | 1034     | 365     | 822      |
| 389  | 3540     | 392     | 1103     | 395     | 872      |
| 419  | 3671     | 422     | 1175     | 425     | 921      |
| 449  | 3795     | 452     | 1251     | 455     | 969      |
| 479  | 3909     | 482     | 1330     | 485     | 1017     |
| 509  | 4018     | 512     | 1413     | 515     | 1064     |
| 539  | 4124     | 542     | 1500     | 545     | 1112     |
| 569  | 4229     | 572     | 1591     | 575     | 1161     |
| 599  | 4332     | 602     | 1684     | 605     | 1210     |
| 629  | 4433     | 632     | 1777     | 635     | 1259     |
| 659  | 4532     | 662     | 1870     | 665     | 1309     |
| 689  | 4629     | 692     | 1962     | 695     | 1359     |
| 719  | 4726     | 722     | 2054     | 725     | 1410     |
| 749  | 4821     | 752     | 2145     | 755     | 1462     |
| 779  | 4914     | 782     | 2235     | 785     | 1515     |
| 809  | 5006     | 812     | 2324     | 815     | 1568     |
| 839  | 5096     | 842     | 2412     | 845     | 1621     |
| 869  | 5186     | 872     | 2498     | 875     | 1674     |
| 899  | 5274     | 902     | 2583     | 905     | 1726     |
| 929  | 5360     | 932     | 2665     | 935     | 1779     |
| 960  | 5444     | 963     | 2746     | 966     | 1831     |
| 990  | 5526     | 993     | 2824     | 996     | 1883     |
| 1020   | 5607     | 1023    | 2901     | 1026    | 1934     |
| 1050   | 5687     | 1053    | 2975     | 1056    | 1985     |
| 1080   | 5765     | 1083    | 3047     | 1086    | 2035     |
| 1110   | 5841     | 1113    | 3115     | 1116    | 2084     |
| 1141   | 5915     | 1144    | 3182     | 1147    | 2132     |
| 1171   | 5986     | 1174    | 3246     | 1177    | 2179     |
| 1201   | 6055     | 1204    | 3306     | 1207    | 2224     |
| 1231   | 6123     | 1234    | 3363     | 1237    | 2268     |
| 1261   | 6188     | 1264    | 3418     | 1267    | 2311     |
| 1291   | 6251     | 1294    | 3472     | 1297    | 2353     |
| 1322   | 6315     | 1325    | 3525     | 1328    | 2395     |
| 1352   | 6379     | 1355    | 3576     | 1358    | 2438     |
| 1382   | 6443     | 1385    | 3628     | 1388    | 2480     |
| 1412   | 6506     | 1415    | 3677     | 1418    | 2522     |

**Table C-2. Kappler CPF III Suit Seam vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 14 April 1998**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
|---------|----------|---------|----------|---------|----------|
| 8       | 3        | 12      | 3        | 15      | 4        |
| 39      | 35       | 42      | 30       | 45      | 46       |
| 68      | 101      | 71      | 92       | 74      | 121      |
| 98      | 188      | 101     | 179      | 104     | 202      |
| 128     | 270      | 131     | 261      | 134     | 277      |
| 158     | 344      | 161     | 334      | 164     | 345      |
| 188     | 413      | 191     | 401      | 194     | 407      |
| 218     | 476      | 221     | 462      | 224     | 464      |
| 248     | 535      | 251     | 520      | 254     | 519      |
| 278     | 591      | 281     | 576      | 284     | 572      |
| 308     | 644      | 311     | 628      | 314     | 624      |
| 338     | 696      | 341     | 678      | 344     | 676      |
| 368     | 747      | 371     | 726      | 374     | 728      |
| 398     | 797      | 401     | 774      | 404     | 783      |
| 428     | 847      | 431     | 820      | 434     | 839      |
| 458     | 897      | 461     | 865      | 464     | 897      |
| 488     | 946      | 491     | 909      | 494     | 957      |
| 518     | 998      | 521     | 952      | 524     | 1019     |
| 548     | 1050     | 551     | 994      | 554     | 1083     |
| 578     | 1103     | 581     | 1035     | 584     | 1147     |
| 608     | 1156     | 611     | 1075     | 614     | 1213     |
| 638     | 1211     | 641     | 1114     | 644     | 1278     |
| 668     | 1265     | 671     | 1153     | 674     | 1344     |
| 698     | 1320     | 701     | 1190     | 704     | 1409     |
| 728     | 1375     | 731     | 1227     | 734     | 1472     |
| 758     | 1430     | 761     | 1263     | 764     | 1535     |
| 788     | 1485     | 791     | 1298     | 794     | 1595     |
| 818     | 1540     | 821     | 1332     | 824     | 1655     |
| 848     | 1594     | 851     | 1365     | 854     | 1713     |
| 878     | 1649     | 881     | 1398     | 884     | 1769     |
| 908     | 1702     | 911     | 1429     | 914     | 1825     |
| 938     | 1753     | 941     | 1459     | 944     | 1878     |
| 969     | 1804     | 972     | 1489     | 975     | 1929     |
| 999     | 1855     | 1002    | 1518     | 1005    | 1979     |
| 1029    | 1905     | 1032    | 1546     | 1035    | 2028     |
| 1059    | 1955     | 1062    | 1574     | 1065    | 2075     |
| 1089    | 2004     | 1092    | 1600     | 1095    | 2121     |
| 1119    | 2051     | 1122    | 1626     | 1125    | 2164     |
| 1150    | 2098     | 1153    | 1650     | 1156    | 2205     |
| 1180    | 2143     | 1183    | 1674     | 1186    | 2244     |
| 1210    | 2186     | 1213    | 1697     | 1216    | 2282     |
| 1240    | 2227     | 1243    | 1719     | 1246    | 2317     |
| 1270    | 2267     | 1273    | 1739     | 1276    | 2351     |
| 1300    | 2307     | 1303    | 1760     | 1306    | 2383     |
| 1331    | 2345     | 1334    | 1779     | 1337    | 2415     |
| 1361    | 2383     | 1364    | 1798     | 1367    | 2446     |
| 1391    | 2421     | 1394    | 1817     | 1397    | 2475     |
| 1421    | 2458     | 1424    | 1833     | 1427    | 2502     |

Appendix C

**Table C-3. Kappler CPF III Boot Material vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 8 April 1998**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
|---------|----------|---------|----------|---------|----------|
| 1       | 0        | 4       | 1        | 7       | 2        |
| 31      | 13       | 34      | 14       | 37      | 25       |
| 61      | 46       | 64      | 52       | 67      | 68       |
| 91      | 94       | 94      | 112      | 97      | 127      |
| 122     | 141      | 125     | 170      | 128     | 185      |
| 152     | 184      | 155     | 222      | 158     | 238      |
| 182     | 223      | 185     | 271      | 188     | 287      |
| 212     | 260      | 215     | 316      | 218     | 331      |
| 242     | 294      | 245     | 357      | 248     | 373      |
| 272     | 324      | 275     | 395      | 278     | 411      |
| 303     | 351      | 306     | 429      | 309     | 445      |
| 333     | 377      | 336     | 460      | 339     | 477      |
| 363     | 402      | 366     | 491      | 369     | 509      |
| 393     | 426      | 396     | 520      | 399     | 540      |
| 423     | 449      | 426     | 548      | 429     | 570      |
| 453     | 472      | 456     | 574      | 459     | 599      |
| 484     | 494      | 487     | 600      | 490     | 628      |
| 514     | 516      | 517     | 625      | 520     | 656      |
| 544     | 538      | 547     | 650      | 550     | 685      |
| 574     | 560      | 577     | 673      | 580     | 714      |
| 604     | 582      | 607     | 697      | 610     | 744      |
| 635     | 604      | 638     | 722      | 641     | 775      |
| 665     | 627      | 668     | 746      | 671     | 807      |
| 695     | 651      | 698     | 770      | 701     | 840      |
| 725     | 675      | 728     | 794      | 731     | 872      |
| 755     | 700      | 758     | 818      | 761     | 905      |
| 785     | 724      | 788     | 842      | 792     | 939      |
| 816     | 749      | 819     | 867      | 822     | 973      |
| 846     | 774      | 849     | 892      | 852     | 1008     |
| 876     | 799      | 879     | 916      | 882     | 1043     |
| 906     | 823      | 909     | 940      | 912     | 1078     |
| 936     | 848      | 939     | 964      | 942     | 1112     |
| 967     | 872      | 970     | 988      | 973     | 1146     |
| 997     | 898      | 1000    | 1012     | 1003    | 1181     |
| 1027    | 923      | 1030    | 1037     | 1033    | 1217     |
| 1057    | 949      | 1060    | 1062     | 1063    | 1252     |
| 1087    | 975      | 1090    | 1088     | 1093    | 1286     |
| 1118    | 999      | 1121    | 1113     | 1124    | 1320     |
| 1148    | 1023     | 1151    | 1137     | 1154    | 1353     |
| 1178    | 1047     | 1181    | 1161     | 1184    | 1385     |
| 1208    | 1071     | 1211    | 1185     | 1214    | 1416     |
| 1238    | 1095     | 1241    | 1209     | 1244    | 1446     |
| 1268    | 1118     | 1272    | 1233     | 1275    | 1477     |
| 1299    | 1140     | 1302    | 1257     | 1305    | 1507     |
| 1329    | 1162     | 1332    | 1280     | 1335    | 1535     |
| 1359    | 1182     | 1362    | 1302     | 1365    | 1561     |
| 1389    | 1204     | 1392    | 1326     | 1395    | 1589     |
| 1419    | 1227     | 1422    | 1351     | 1425    | 1617     |

**Table C-4. Kappler CPF III Boot Seam vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 15 April 1998**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
|---------|----------|---------|----------|---------|----------|
| 11      | 5        | 14      | 6        | 17      | 7        |
| 42      | 29       | 45      | 33       | 48      | 34       |
| 72      | 61       | 75      | 68       | 78      | 67       |
| 102     | 99       | 105     | 109      | 108     | 103      |
| 132     | 134      | 135     | 147      | 138     | 136      |
| 162     | 166      | 165     | 181      | 168     | 166      |
| 192     | 190      | 195     | 206      | 198     | 187      |
| 223     | 205      | 226     | 222      | 229     | 199      |
| 253     | 217      | 256     | 236      | 259     | 210      |
| 283     | 229      | 286     | 250      | 289     | 220      |
| 313     | 239      | 316     | 264      | 319     | 229      |
| 343     | 249      | 346     | 276      | 349     | 238      |
| 373     | 258      | 376     | 288      | 379     | 247      |
| 404     | 267      | 407     | 300      | 410     | 255      |
| 434     | 276      | 437     | 310      | 440     | 263      |
| 464     | 284      | 467     | 321      | 470     | 271      |
| 494     | 291      | 497     | 331      | 500     | 279      |
| 524     | 299      | 527     | 341      | 530     | 286      |
| 554     | 306      | 557     | 350      | 560     | 293      |
| 585     | 313      | 588     | 359      | 591     | 299      |
| 615     | 320      | 618     | 367      | 621     | 306      |
| 645     | 326      | 648     | 376      | 651     | 312      |
| 675     | 331      | 678     | 384      | 681     | 317      |
| 705     | 337      | 708     | 391      | 711     | 320      |
| 735     | 340      | 738     | 398      | 741     | 320      |
| 766     | 340      | 769     | 405      | 772     | 320      |
| 796     | 340      | 799     | 412      | 802     | 320      |
| 826     | 340      | 829     | 418      | 832     | 320      |
| 856     | 340      | 859     | 424      | 862     | 320      |
| 886     | 340      | 889     | 430      | 892     | 320      |
| 916     | 340      | 919     | 435      | 922     | 320      |
| 947     | 340      | 950     | 438      | 953     | 320      |
| 977     | 340      | 980     | 441      | 983     | 320      |
| 1007    | 340      | 1010    | 444      | 1013    | 320      |
| 1037    | 340      | 1040    | 446      | 1043    | 320      |
| 1067    | 340      | 1070    | 452      | 1073    | 320      |
| 1097    | 340      | 1100    | 455      | 1103    | 320      |
| 1128    | 340      | 1131    | 455      | 1134    | 320      |
| 1158    | 340      | 1161    | 455      | 1164    | 320      |
| 1188    | 340      | 1191    | 455      | 1194    | 320      |
| 1218    | 340      | 1221    | 455      | 1224    | 320      |
| 1248    | 340      | 1251    | 455      | 1254    | 320      |
| 1278    | 340      | 1281    | 455      | 1284    | 320      |
| 1309    | 340      | 1312    | 455      | 1315    | 320      |
| 1339    | 340      | 1342    | 455      | 1345    | 320      |
| 1369    | 340      | 1372    | 455      | 1375    | 320      |
| 1399    | 340      | 1402    | 455      | 1405    | 320      |

Appendix C

**Table C-5. Kappler CPF III Crotch Seam vs. GB Liquid, 10 g/m<sup>2</sup>  
Modified Static Diffusion Test, 15 April 1998  
Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
|---------|----------|---------|----------|---------|----------|
| 2       | 1        | 5       | 2        | 8       | 4        |
| 33      | 49       | 36      | 31       | 39      | 36       |
| 63      | 115      | 66      | 66       | 69      | 81       |
| 93      | 183      | 96      | 106      | 99      | 133      |
| 123     | 247      | 126     | 145      | 129     | 181      |
| 153     | 306      | 156     | 180      | 159     | 225      |
| 183     | 360      | 186     | 212      | 189     | 265      |
| 214     | 401      | 217     | 236      | 220     | 295      |
| 244     | 431      | 247     | 250      | 250     | 317      |
| 274     | 459      | 277     | 263      | 280     | 336      |
| 304     | 486      | 307     | 275      | 310     | 355      |
| 334     | 511      | 337     | 286      | 340     | 372      |
| 364     | 535      | 367     | 297      | 370     | 389      |
| 395     | 559      | 398     | 307      | 401     | 404      |
| 425     | 583      | 428     | 318      | 431     | 420      |
| 455     | 605      | 458     | 327      | 461     | 436      |
| 485     | 627      | 488     | 337      | 491     | 450      |
| 515     | 647      | 518     | 346      | 521     | 464      |
| 545     | 667      | 548     | 355      | 551     | 477      |
| 576     | 685      | 579     | 364      | 582     | 490      |
| 606     | 703      | 609     | 372      | 612     | 502      |
| 636     | 720      | 639     | 380      | 642     | 513      |
| 666     | 736      | 669     | 387      | 672     | 524      |
| 696     | 752      | 699     | 394      | 702     | 534      |
| 726     | 767      | 729     | 401      | 732     | 544      |
| 757     | 782      | 760     | 408      | 763     | 553      |
| 787     | 797      | 790     | 415      | 793     | 562      |
| 817     | 810      | 820     | 422      | 823     | 571      |
| 847     | 823      | 850     | 428      | 853     | 580      |
| 877     | 837      | 880     | 434      | 883     | 588      |
| 907     | 850      | 910     | 441      | 913     | 596      |
| 938     | 862      | 941     | 447      | 944     | 604      |
| 968     | 875      | 971     | 453      | 974     | 612      |
| 998     | 887      | 1001    | 459      | 1004    | 620      |
| 1028    | 900      | 1031    | 465      | 1034    | 627      |
| 1058    | 912      | 1061    | 471      | 1064    | 635      |
| 1088    | 924      | 1091    | 478      | 1094    | 643      |
| 1119    | 936      | 1122    | 484      | 1125    | 651      |
| 1149    | 948      | 1152    | 490      | 1155    | 659      |
| 1179    | 960      | 1182    | 497      | 1185    | 666      |
| 1209    | 971      | 1212    | 504      | 1215    | 673      |
| 1239    | 983      | 1242    | 510      | 1245    | 680      |
| 1269    | 994      | 1272    | 517      | 1275    | 688      |
| 1300    | 1005     | 1303    | 524      | 1306    | 694      |
| 1330    | 1016     | 1333    | 530      | 1336    | 701      |
| 1360    | 1027     | 1363    | 537      | 1366    | 708      |
| 1390    | 1038     | 1393    | 544      | 1396    | 716      |
| 1420    | 1050     | 1423    | 552      |         |          |

Appendix C

**Table C-6. Kappler CPF III Zipper/Material Interface vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 8 April 1998**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

| Minutes | Swatch 1 | Minutes | Swatch 2 | Minutes | Swatch 3 |
|---------|----------|---------|----------|---------|----------|
| 10      | 2        | 13      | 2        | 16      | 3        |
| 40      | 19       | 43      | 24       | 46      | 27       |
| 70      | 57       | 73      | 64       | 76      | 70       |
| 100     | 108      | 104     | 113      | 107     | 119      |
| 131     | 156      | 134     | 160      | 137     | 166      |
| 161     | 200      | 164     | 204      | 167     | 208      |
| 191     | 242      | 194     | 243      | 197     | 247      |
| 221     | 279      | 224     | 280      | 227     | 283      |
| 251     | 314      | 254     | 313      | 257     | 317      |
| 281     | 346      | 285     | 344      | 288     | 348      |
| 312     | 375      | 315     | 371      | 318     | 375      |
| 342     | 402      | 345     | 397      | 348     | 401      |
| 372     | 428      | 375     | 422      | 378     | 427      |
| 402     | 454      | 405     | 447      | 408     | 452      |
| 432     | 479      | 435     | 469      | 438     | 476      |
| 463     | 504      | 466     | 492      | 469     | 500      |
| 493     | 530      | 496     | 513      | 499     | 524      |
| 523     | 555      | 526     | 535      | 529     | 548      |
| 553     | 581      | 556     | 556      | 559     | 573      |
| 583     | 607      | 586     | 577      | 589     | 599      |
| 613     | 635      | 616     | 599      | 619     | 626      |
| 644     | 665      | 647     | 622      | 650     | 655      |
| 674     | 697      | 677     | 645      | 680     | 685      |
| 704     | 729      | 707     | 668      | 710     | 715      |
| 734     | 763      | 737     | 692      | 740     | 747      |
| 764     | 798      | 767     | 716      | 770     | 779      |
| 795     | 833      | 798     | 741      | 801     | 812      |
| 825     | 870      | 828     | 767      | 831     | 846      |
| 855     | 907      | 858     | 792      | 861     | 881      |
| 885     | 943      | 888     | 818      | 891     | 916      |
| 915     | 980      | 918     | 845      | 921     | 951      |
| 945     | 1016     | 948     | 870      | 951     | 986      |
| 976     | 1052     | 979     | 896      | 982     | 1022     |
| 1006    | 1090     | 1009    | 923      | 1012    | 1060     |
| 1036    | 1129     | 1039    | 951      | 1042    | 1098     |
| 1066    | 1167     | 1069    | 979      | 1072    | 1136     |
| 1096    | 1203     | 1099    | 1007     | 1102    | 1172     |
| 1127    | 1237     | 1130    | 1034     | 1133    | 1208     |
| 1157    | 1271     | 1160    | 1060     | 1163    | 1243     |
| 1187    | 1305     | 1190    | 1087     | 1193    | 1278     |
| 1217    | 1338     | 1220    | 1113     | 1223    | 1312     |
| 1247    | 1369     | 1250    | 1139     | 1253    | 1347     |
| 1278    | 1400     | 1281    | 1164     | 1284    | 1381     |
| 1308    | 1430     | 1311    | 1188     | 1314    | 1412     |
| 1338    | 1458     | 1341    | 1212     | 1344    | 1443     |
| 1368    | 1485     | 1371    | 1234     | 1374    | 1473     |
| 1398    | 1513     | 1401    | 1258     | 1404    | 1504     |
| 1429    | 1541     | 1432    | 1284     | 1435    | 1543     |

Appendix C